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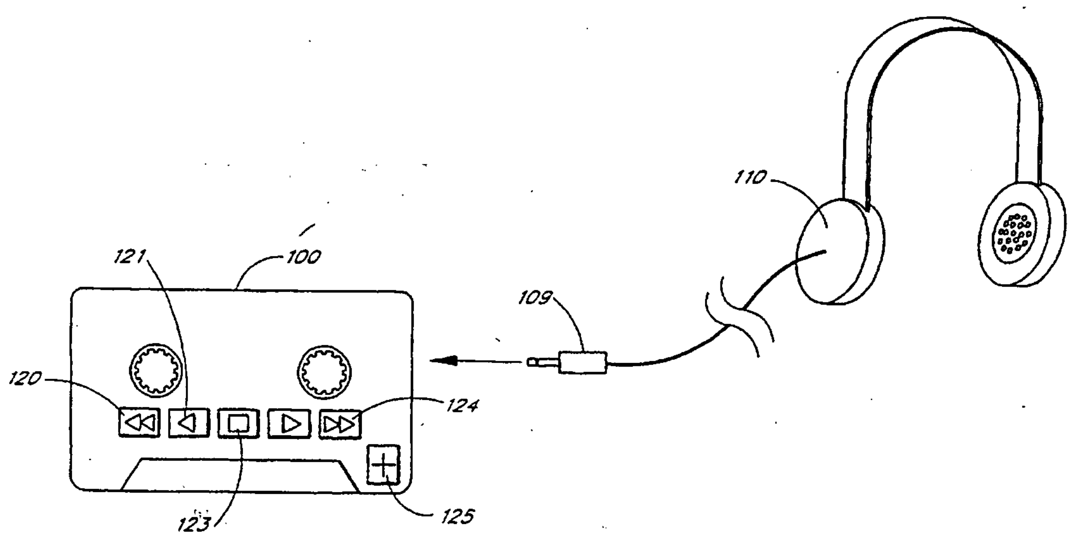
(54) Title: ELECTRONIC CASSETTE APPARATUS AND METHOD



(57) Abstract: A digital-audio electronic cassette that is functionally interchangeable with the conventional tape cassette is described. The electronic cassette provides digital-audio data in a package and format that is compatible with the shape and size of the tape cassette. A signal processor in the electronic cassette converts the stored digital-audio data in a format such as WAV or MP3 into a digital data stream that is converted into an analog signal and provided to a transducer that is magnetically coupled to tape read head in a conventional cassette tape player. A display and controls on the electronic cassette allow a user to view the names of the digital-audio files and manipulate the files. The digital-audio sound files are stored in internal memory or in removable memory. The electronic cassette can be used in conventional analog tape recorder to produce digital-audio files that can be uploaded to a computer.

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INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G11C7/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G11C G06F G11B H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 790 423 A (KATZ DONALD R ET AL) 4 August 1998 (1998-08-04) the whole document ---	1-13, 16-46, 49-52
X	DE 41 35 220 C (SMARTDISKETTE GMBH) 8 April 1993 (1993-04-08) the whole document ---	1,5,20, 26, 30-32, 39,49
A	US 5 794 164 A (BECKERT RICHARD D ET AL) 11 August 1998 (1998-08-11) column 4, line 26-41; figure 1 column 6, line 19-59 column 9, line 37-42 ---	47,48

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 December 2000	20.12.2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Czarik, D

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/08878

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication where appropriate, of the relevant passages	Relevant to claim No.
A	DE 197 41 503 A (PONTIS MESTECHNIK GMBH) 1 April 1999 (1999-04-01) column 1, line 47-64 -----	47,48

In. .ational application No.
PCT/US 00/08878

INTERNATIONAL SEARCH REPORT

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-46 49-52

   An electronic digital audio-cassette. Digital audio data can be downloaded from a computer to the audio-cassette's memory.

2. Claims: 47-48

   A vehicle audio system comprising a memory interface that can read solid state floppy disk cards.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 00/08878

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 5790423	A	04-08-1998	AU	6278996	A	15-01-1997
			WO	9700484	A	03-01-1997
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			EP	1018117	A	12-07-2000

ELECTRONIC CASSETTE APPARATUS AND METHOD

Description of **WO0060599**

ELECTRONIC CASSETTE APPARATUS AND METHOD
Background of the Invention
Field of the Invention
The present invention relates to devices for storing, recording, or playing digital-audio data.

Background
Since its introduction in the early 1970's, the compact tape cassette has become a mainstay of portable music devices and car audio systems. Audio Compact Disk (CD), introduced in the early 1980's, has not replace the tape cassette. In fact, the markets for audio CD systems and tape systems appear to be largely complementary. The tape cassette remains popular in applications such as automobiles, trucks, boats, portable stereos, and the like, where the background noise, vibration, and cost factors favor the use of the low-cost, rugged, tape cassette.

Conventional tape cassettes are analog devices. Recent advances in digital-audio processing and storage technology have made digital devices more attractive for storage of audio information, and, thus, digital-audio processing appears to be replacing analog-audio processing. Techniques for compressing, transmitting, and storing digital-audio information currently provide capabilities that cannot be achieved by analog means.Personal computers are routinely used to play audio program materials such as audio CDs, digital-audio files downloaded from the Internet, and audio programs generated by computer programs, etc.

A recent audio high performance compression standard commonly used to store digital-audio information is the, so called, MP3 standard. The MP3 standard is the audio portion of the very popular MPEG (Motion Picture's Expert Group) audiolvideo standard. MP3 provides high compression ratios without significantly degrading audio quality. Afollow-on to MP3 is the MP4 standard which promises even higher levels of performance. Digital-audio files arealso stored in uncompressed form using the WAV format provided by MicrosoftWindows.

Unfortunately, the of millions of existing tape cassetteplayers cannot take advantage of the new digitalaudio formats because these devices are limited to the analog magnetic tape format.

Summarv of the Invention
The present invention solves these and other problems by providing a digital-audio electronic cassette that is functionally interchangeable with the conventional analog tape cassette. In on embodiment, the electronic cassette provides storage of digital-audio sound files such asWAV files, MP3 files, MP4 files, and the like. The electronic cassette provides digital-audio data in a package and format that is compatible with the shape and size of the tape cassette. A signal processor in the electronic cassette converts the stored digital-audio data into a digital data stream and a digital-to-analog converter in the electronic cassette converts the digital data stream into analog data. The analog data is provided to a transducer in the electronic cassette that communicates with the tape head in a standard cassette player, thereby allowing the audio informationto be passed to the cassette player and played on speakers attached to the cassette player.

In one embodiment, the electronic cassette also provides a computer interface that allows a user to attach the electronic cassette to a computer, such as a personal computer, and download digital-audio sound files to the electronic cassette. A computer program is provided that allows the user to manipulate, select, delete, rearrange, and organize the digital-audio sound files in the electronic cassette.

In one embodiment, the electronic cassette includes a display thatallows the user to view the names of the digital-audio sound files stored on the electronic cassette. Various user controls (e. g., buttons) areoptionally provided on the electronic cassette toallow the user tomanipulate the sound files and the data stored in the electronic cassette. Using the controls, the user can delete files, disable files, enable files, rearrange files, and control various aspects of the operation of the electronic cassette.

In one embodiment, the sound files are stored in a nonvolatile memory permanently encased in the electronic cassette. In an alternate embodiment, the sound files are stored in a removable storage device such as a miniaturized solid state floppy disk card (SSFDC) or microdisk drive. The removable storage device can also be inserted into asuitably equipped sound system, such as, for example, an automobile DIN-compatible sound system.

In yet another embodiment, the electronic cassette provides recording capabilities. In a recording embodiment, a recording transducer in the electronic cassette communicates with a write tape head in a cassette tape recorder. Analog signals from the recording transducer are converted to digital samples that are passed to a signal processor where the digital samples aresuitably processed to create a digital-audio sound file. The user can upload the recorded information from the electronic cassette into a standard personal computer forlong-term storage or for copying onto other electrical cassettes or other media.

Brief Description of the Drawings

The various features of the invention will now be described with reference to thefollowing drawings.

Figure 1 A shows an electronic cassette connected to a personal computer.

Figure 1B shows an electronic cassette used with a conventional analog cassette tape deck to provide digital-audio sound from the conventional analog tape deck.

Figure 1 C shows an electronic cassette used with headphones as astand-alone personal digital-audio device.

Figure 2A shows a removable digital-audio storage device connected to a personal computer.

Figure 2B shows a removable digital-audio storage device used with a sound system configured to read data from the removable digital-audio storage device.

Figure 2C shows a removable digital-audio storage device used in connection with an electronic cassette.

Figure 3 shows an electronic cassette with a display that lists the sound files stored on the electronic cassette.

Figure 4, is a block diagramillustrating the functional systems in the electronic cassette.

Figure 5A shows the mechanical aspects of a tape motion sensing system for an electronic cassette with a single capstan.

Figure 5B shows the mechanical aspects of a tape motion sensing system for an electronic cassette with two capstans.

Figure 6Aillustrates an optical tape motion sensor that uses a belt to connect two takeupreels.

Figure 6B illustrates a magnetic sensor system for sensing tape motion using a strip of pre-recorded magnetic tape.

Figure6C illustrates a magneticloptical sensor system for sensing tape motion.

Figure 7 illustrates a tape motion sensing system that does not use a belt to connect the two takeup reels.

In the drawings, like reference numbers are used to indicate like or functionally similar elements. The first digit of eachthree-digit reference numbergenerally indicate the figure number in which the referenced item first appears. The first two digits of each four-digit reference number generally indicate the figure number in which the referenced item first appears.

Detailed Description of the PreferredEmbodiment

Figure 1A shows an electronic cassette 100 attached to a computer 104 by an adapter cable 102. The adapter cable 102 can attach to any computer port including, for example, aparallel port, a fire wire bus port, a universal serial bus (USB) port, an RS232 serial port, an ethernet port, a network port, a PCMCIA port, and the like.

The adapter cable 102 can also be a"virtual"cable created by an infrared link (e. g., an industry standard IRDlink) wherein an infraredtransmitterlreceiver in the personal computer 104 communicates with an infraredtransmitterlreceiver in the electronic cassette 100. The adapter cable 102 can also be a"virtual"cable created by a radio frequency(RF) link wherein an RFtransmitterlreceiver in the personal computer 104 communicates with an RFtransmitterlreceiver in the electronic cassette 100. The use of a virtual connection (e. g., an infrared or RF connection) obviates the need for physical cables between the computer 104 and the electronic cassette 100. Digital-audio sound files aredownloaded from the computer 104 into the cassette 100 through the adapter cable 102. The sound files are stored, in a nonvolatile memory (or a volatile memory with battery backup) in the electronic cassette 100, for later playback.

Once the sound files have been downloaded into the electronic cassette 100, the electronic cassette is detached from the cable 104 and the electronic cassette 100 is inserted into a standard tape cassette player such as a car audio tape player 106 shown in Figure1B. The external size, shape, and form factor of the electronic cassette 100 is compatible with the external size, shape and form factor of a conventional tape compact cassette so that the electronic cassette 100 can be inserted into a conventional compact cassette player.

As discussed in more detail below, when inserted into the tape player 106 the electronic cassette 100 functions in a manner similar to a standard tape cassette. The electronic cassette 100 senses tape movement commands, such as fast-forward, rewind, and play, from the tape player 106. In the play mode, the electronic cassette 100 provides a magnetic signal, resembling the magnetic signal produced by a moving magnetic tape, to a read head in the tape player 106. The tape player 106 senses the magnetic signal from the electronic cassette 100 as itwould sense the magnetic signal from an actual piece of magnetic tape traveling past the tape head.

Unlike a conventional magnetic tape cassette, which isstrictly a passive device, the electronic cassette 100 can provide information to a playback source without the need for the tape player 106. As shown in Figure 1 C, a pair of

headphones 110 can be plugged into the electronic cassette 100 using a headphone connector 109. In the embodiment shown in Figure1C, the electronic cassette 100 uses its own interna battery power to drive the headphones 110.

Control buttons such as a rewind control 120, a reverse play control 121, a pause control122, a forward play control 123, a fast-forward control 124, and a volume control 125 are provided on the electronic cassette 100 allow the user to control the operation of the electronic cassette and the playback of sound files through the headphones 110. The controls120-125 operate in a manner similar to the controls on the conventional tape deck 106.

As discussed above, the electronic cassette 100 can be used in connection with a built-in memory. The electronic cassette 100 can also be used in connection with a removable storage device 200 shown in Figure 2A. The removable storage device 200 includes, for example, devices such as a miniaturized solid state floppy disk card (SSFDC), a micro disk drive, a flash memory, and the like.

The removable storage device 200 ispreferably a non-volatile storage device that retains stored data, even when the device has been disconnected from a power source. Disk drives, such as hard disks and floppy disks, are non-volatile memories. Other types of non-volatile memories include a Read Only Memory (ROM), an SSFDC, a flash memory, and the like.

Disk drives have traditionally been relatively large and sensitive to shock, and thus ill suited to some applications such as the electronic cassette 100. However, recent advances in miniaturization have led to disk drives that are suitable for use in the electronic cassette 100. For example, the IBM 170 MBI 340 MB micro drives are approximately 3.5 cm by 4.5 cm and can withstand the shock and vibration loads expected in portablelhandheld equipment.

Flash Memories are non-volatile, very small, require little power, and are very shock resistant. One such Flash Memory device is the Toshiba TC5816. The TC5816 is a single 16 Mb (megabit)Electrically Erasable and Programmable
Read Only Memory(EEPROM) device, approximately 3.5 cm by 4.5 cm. The SSFDC is a serial type of memory device which provides automatic erase and re-program operations, much like a floppy disk. This capability makes the SSFDC ideal for applications such as solid state file storage, voice recording, image recording for digital cameras, and other systems which require high density, non-volatile data storage.

Digital sound files are loaded into the removable storage device 200 by inserting the removable storage device 200 into an adapter 202 shown in Figure 2A. The adapter 202 can be the electronic cassette 100 or the adapter 202 can be a special adapter configured to connect the removable storage device 200 to the computer 104.

The adapter 202 is connected to the computer 104, thereby allowing the user to perform the functions of downloading sound files, uploading sound files, rearranging sound files, etc. in the removable storage device 200. As shown in Figure 2B, the removable storage device 200 can be removed from the adapter 202 and inserted into a memory slot 205 in a media player 206. The media player 206 can be a portable playback device, an automobile sound system, and the like.

The removable storage device 200 can also be inserted into the electronic cassette 100 as shown in Figure 2C. With the removable storage device 200 inserted into the electronic cassette 100, the electronic cassette 100 is inserted into the tape player 106 for playback of the digital-audio sound files stored on the removable storage device 200. Storing sound files on the removable storage device 200 provides considerable flexibility because the user can play the sound files back using any of the playback devices listed above.

In one embodiment, the electronic cassette 100 includes a display 302, shown in Figure 3. The display 302 shows information about the digital-audio sound files stored in the electronic cassette 100. Information about the sound files includes, for example, names of the sound files, name of artists, playback times,ordering of the sound files,enableldisable status of the sound files, and operating modes of the electronic cassette 100.

As shown in Figure 3, the display 302 may inclue, for example, a textfield 306 that shows the name of the sound file, the name of the artist, playback time, etc. The display 302 also includes a check box 305, and a cursor 304. The display 302 can also be used to display other information such as, for example, status of a battery power supply, the number of sound files stored, operating modes of the electronic cassette 100, the percentage of the available memory used in the electronic cassette 100, the amount of memory still available in the electronic cassette 100, etc.

Along with the optional display 302, the electronic cassette 100 can include anenableldisable button 310, a scroll-up button 312, a scroll-down button 313, a mode-select button 316, and areorder button 318.

The display 302 includes a check box 305 for each sound file. The check box 305 indicateswhether the soundfile will be played or whether the sound file will not be played as part of a playlist for the electronic cassette 100. Theenableldisable button 310 is used to check or uncheck the check box 305. A cursor 304 is used to indicate which sound file listed in the display 302 iscurrently selected. The selected sound file may be enabled, disabled, moved up or down in the playlist, etc. The scroll buttons 312 and 313 are used to move the cursor 304 up and down.

If the electronic cassette 100 is contains more sound files than can be shown at one time on the display 302, then the

scrolling button will also scroll names onto the display 302 and off of the display 302 in a manner similar to a conventional window on the Graphical User Interface(GUI) system such as, for example, the MicrosoftWind OWSTM system.

Figure 4 is a block diagram showing the various functional blocks of the compact cassette 100. Operation of the compact cassette 100 iscontrolled by a Micro Control Unit(MCU) 402, such as, for example, amicroprocessor, a state machine, a Digital Signal Processor (DSP), a functional block on an Application Specific Integrated Circuit (ASIC), etc. One example of an MCU is the PIC processor supplied by Microchip Technology Inc.

The MCU 402 communicates with a computer host interface 406. The host interface 406 communicates with the adapter cable 102 shown in Figure 1. The host interface 406 can be a universal serial bus(USB) interface, aparallel port interface, an infraredIRD interface, a serial port interface, anRS-232 interface, a parallel port interface, a fire-wire interface, an RF interface, a network interface, aPCMCIA interface, an ethernet interface, and the like.

Outputs from an optional user control system 408 are provided to an input of the MCU 402. The user control system 408 includes user-input controls such as theenableldisable button 310, the scrolling buttons 312,313, the mode controls 316, the tape controls 120-125, etc. The MCU 402 also receives inputs from a motion control system 410 that includes one or more tape motion sensors as described in connection with Figures 5,6, and 7.

An MCU memory 412 provides storage for programs and data that are used by the MCU 402. Asound-file memory system 414 is also provided to the MCU 402. The sound-file memory 414 stores the digital sound files. The sound-file memory 414 preferably includes a volatile memory (e. g., static RAM or dynamic RAM) with battery backup, or a non-volatile memory, such as a flash ram, SSFDC, micro drive, and the like as discussed above. The MCU 402 provides data and control signals to an input of an optional display system 403. The display system 403 includes a visual display, such as the display 300, shown in Figure 3. The MCU 402 communicates with a power control system 430 that distributes power among the functional blocks of the electronic cassette 100. Power is supplie to the power control system by a battery 428.

The MCU 402 also communicates with a Digital Signal Processor (DSP) 404. In some embodiments, the MCU 402 and the DSP 404 are combined into asingle processor. The DSP 404 communicates with DSP memory 416 that provides programs and data storage for the DSP 404. An output of the DSP 404 is provided to a digital input of a digital analog converter418. An analog output of the digital analog converter 418 is provided to an analog input of an amplifier 420. An output of the amplifier 420 is provided to an input of a transducer system 422, and, optionally, to a headphonelline-out jack 421. For embodiments where the electronic cassette operates as a recording device, an output of the transducer system 422 is provided to an input of an amplifier 424. An output of the amplifier 424 is provided to an analog input of an analog-to-digital converter 426. The digital output of the analog converter 426 is provided to an input of the DSP 404.

In one embodiment, electrical power is also supplie to the power control system 430 by the host interface 406 whenever power is available from the host interface 406. Some computer buses, such as the USB,fire-wire, andPCMCIA buses, are configured to provide modest amounts of power to devices connected to the bus. Use of power from the bus, rather than the battery 428, conserves power on the battery 428. The power controller 430 senses that the electronic cassette 100 is connected to a power-capable bus and draws power from the host interface 406 rather than the battery 428.

When the electronic cassette 100 is downloading data from the computer 104 or uploading data to the computer 104, the MCU 402 communicates with the computer 104 through the host interface 406. The MCU receives data and commands from the computer 104 through the host interface 406. The MCU 402 stores the soundfile data received from the computer 104 in the sound-file memory 414.

In response to user inputs from the user control system 408, the MCU operates on the stored sound files, sends display information to the display system 403, etc. When the electronic cassette 100 is inserted into a cassette playback device, such as the cassette deck 106, the MCU 402 receives tape motion commands from the motion sensor system 410. The sensor system 410 informs the MCU 402 that the cassette deck 106 has initiated a tape operation (e. g., play, rewind,fast-forward, etc.). In response to a play command, the MCU 402 retrievessound-file data from thesound-file memory 414 and passes thesound-file data to the DSP 404.

The DSP 404 performs decompressiónandlor decryption operations, if needed, to convertsound-file data into a sequence of digital-audio samples. The digital-audio samples are from the DSP 404 are provided to thedigital to analog converter 418 for conversion to analog format. The analog signals provided by the digital-to-analog converter 418 are amplified by the amplifier 420 and provided to the transducer 422.

In one embodiment, the transducer system 422 is similar to the read head (in the tape player 106), and includes a magnetic core having a gap and a coil of wire wrapped around the core. Atime-changing current in the coil produces atime-changing magneticfield in the gap. The transducer system 422 is magnetically coupled to the read head. Thetime-changing magnetic field produced by the transducer system 422 is coupled to the read head in the tape player 106. The read head in the tape player 106 senses the time-changing magneticfields produced by the transducer system 422 as it would sense the time-changing magneticfields produced by a strip of magnetic tape passing over the read head. The tape player 106 amplifies a signal produced by the read head and provides the

amplified signal to speakers.

In one embodiment, the electronic cassette 100 provides a recording mode where the electronic cassette is used as a digital audio recording device. When used as a recording device, the electronic cassette 100 is inserted into a tape cassette recorder having a record head. The record head generates atime-changing magneticfield that is coupled to the transducer 422. The transducer 422 converts thetime-changing magnetic fields produced by the record head into an electrical signal that is amplified by the amplifier 424. The signals amplified by the amplifier 424 are converted into a stream of digital-audio samples by the analog-to-digital converter 426. The digital-audio samples produced by the analog converter 426 are provided to the DSP 404 where they are processed and formatted into a desired digital-audio format such as WAV, MP3, MP4, etc. The digital-audio formatted data is passed to the MCU 402 and stored in the sound-file memory 414.

Information stored in thesound-file memory 414, either having been previouslydownloaded from the computer 104 or recorded using the analog-to-digital converter 426 and DSP 404, can beuploaded into the computer 104. In the upload process, the MCU 402 reads the sound file information from the sound-file memory 414 and passes that digital information to the host interface 406. The host interface 406 in turn provides the digital sound file information to the computer 104. The MCU 402 can also provide addition information to the host computer 104, including, for example, the number of files stored in thesound-file memory 414, the names of the files stored in thesound-file memory 414, the status, such as enableldisable status, of the sound files in the memory 414, the length of the sound files stored in the sound-file memory 414, the operating state of the electronic cassette 100, etc.

In addition to sensingplaylrecord tape motions, the motion sensor system 410 can sense that the tape player 106 is attempting to perform an operation such as a fast-forward or rewind. The tape motion information from the motion sensor system 410 is provided to the MCU 402. The MCU 402 simulates the operation that wouldoccur in a tape cassette. For example, when the MCU 402 receives a fast-forward indication from the motion sensors 410, the MCU 402 skips forward through thesound-file memory 414. In one embodiment of the fast-forward mode, the MCU 402 jumps through portions of the <RTI sound-file memory 414 andplays small sections of the digital-audio data similar to the way an audio CD playerplays small excerpts as itfast-forwards through an audio CD. When the MCU 402 senses a reverse operation, it skips back through the digital-audio data and plays small portions of the data. Thus,unlike a conventional magnetic tape cassette which does not provide the user with recognizable information in reverse, the electronic cassette can conveniently provide small bursts of forward play information during a rewind operation,allowing the user to determinehow far the rewind operation has gone.

In an alternate embodiment of the fast-forward and rewind modes, the MCU 402 does not skip through the audio information in aparticular sound file, but, rather, the MCU 402 jumps from one sound file to the next sound file stored in thesound file memory 414 (similar to thetrack-select feature provided by most CD players).

In one embodiment of the electronic cassette 100, a mode button on the compact cassette 100allows the user to select whichfast-forward) rewind mode the electronic cassette 100 uses. In one mode, the electronic cassettefast-forwardsirewinds in a more or lessconventional fast-forwardirewind mode where it runsquickly through a song playing small excerpts from the song or file. In the second mode, the electronic cassette 100 skips from track to track during thefast-forwardirewind operation.

The MCU 402 works in connection with the power control 430 to conserve power and distribute power inside the electronic cassette 100 to those systems that need power for aparticular operation. When the electronic cassette100 is downloading information from a computer 104 through the host interface 406, the MCU 402 can shut down the DSP 404, the digitallanalog converter 418, the amplifier 420, and optionally, the amplifiers 424 and theanalog to digital converter 426. Conversely, the MCU 420 can shut down the host interface 406 when it senses that the electronic cassette 100 is in play mode, in fast-forward mode, in rewind mode, or is not connected to the computer 104. The MCU 402 willalso power down the motion sensor system 410 when it senses that the electronic cassette 100 is not inserted in the tape player 106 or when the motion sensor system 410 does not need power.

Motion Sensors
Figures 5A and 5B illustrate various mechanical aspects of the electronic cassette 100 and the motion control system 410 used to sense operation of the tape player 106. Figure 5A shows an electronic cassette 100 configured to a tape player having a player 106 has entered a play (or record) mode and the MPU 402 begins a play (or record) operation as described in connection with Figure 4.

In addition to the features shown in Figure 5A, Figure 5B shows a second capstan 550 and a second pinch roller558.

In one embodiment, the sensor 510 provides direction information to the MPU 402 so that the MPU 402 can simulate forward-play and reverse-play operations. Forward-play andreverse play modes are useful in a conventional tape cassette because the use of two modes doubles the playing time of the magnetic tape cassette. The reverse-play mode is not required on the electronic cassette 100 because the audio program material is stored in thesound-file memory 414 rather than on magnetic tape. Reverse play mode is,however, provided in one embodiment of the electronic cassette 100 to simulate the operation of a standard cassette.

Forward and reverse play modes are also used in some embodiments to provide enhanced operation. For example, the user may use the electronic cassette 100 to simulate the two sides of a standard magnetic cassette.

The user can designate one set of audio files to be played in the forward direction and a different set of audio files for play in the reverse direction.

In fast-forward mode, the tape player 106 disengages the capstan 520 from the pinchroller 518 and drives the belt 508 using the takeup reels 504 and 506. In fast-forward (or rewind) the speed of the belt 508 is much faster than the speed of the belt 508 in the play mode. As described below, the tape motion sensor 510 provides enough information to the MPU 402 toallow the MPU 402 to determine tape speed and tape direction. The MPU 402 determines that the tape is moving in a speed and direction corresponding to fast-forward or rewind mode. When the MPU 402 senses that the belt 508 is moving with a speed corresponding to fast-forward or rewind, then the MPU 402 simulates fast-forward or rewind as described in connection with Figure 4.

Many tape players automatically switch from rewind mode to play mode when the end of the tape is reached. In one embodiment, a brake 514 is provided toallow the electronic cassette 100 to simulate anend-of-tape condition. The MPU 402 simulates end-of-tape by using the brake 514 to stop the motion of the belt 508. The MPU 402 typically simulates an end-of-tape when a rewind operation as reached the beginning of thesound-file memory 414, or a fast-forward (or play) operation as reached the end of the sound-file memory 414. In one embodiment, the brake 514 is adirectional brake that allows the MPU 402to freeze the motion of the belt 508 in a selected directionwhile still allowing the belt 508 to move in the opposite direction. In an alternate embodiment, the brake 514 operates on one or both of the takeup spools 504,506, as shown in connection with Figure 7.

Various embodiments of the sensor system 510 are shown in Figures6A-6C. Figure 6A shows an optical system having an optical transmitter 601 and an optical sensor 602. In the optical system of Figure 6A, the belt 508 is has various optical properties that are sensed by the optical sensor 602. In one embodiment, the belt 508 has sections where it is transparent and sections where it is opaque to the optical energy produced by the transmitter 601.

Figure 6A shows a transmission system where the optical sender 601 and the optical receiver 602 on opposite sides of the belt 508 and the sensor 602 senses optical energy that passes through the belt 508.

The sensor system 510 can also be configured as a reflection system wherein the sender 601 and receiver 602 are positioned on the same side of the belt 508 such that the receiver 602 senses optical signals reflected from the belt 508. In the reflection embodiment, the information needed to allow the MPU to sense motion of the belt 508 is encoded by varying thereflective properties of the belt 508 at the optical wavelengths produced by the sender 601.

The optical system shown in Figure 6A is simple, inexpensive, and reliable, but in some applications may have the disadvantage of requiring relatively more power than other motion sensor embodiments. In particular, the optical transmitter 601 uses electrical power (e. g., battery power) to produce the optical signal that is received by the optical receiver 602. Figure 6B shows a magnetic sensor embodiment of a motion sensor. The magnetic sensor includes a read head 608. In Figure 6B the belt 508 configured as a magnetic tape with pre-recorded signals. As the belt 508 moves past the read head608, the belt 508 produces a time-varying magneticfield and thistime-varying field is sensed by the read head 610. In response to the time-varying magnetic field, the read head 610 produces anelectrical signal, which is amplified, digitized, and provided to the MPU 402. The MPU 402 ascertains the direction of travel and the speed of the belt 508 by examining the signal produced by the tape head 610.

In one embodiment, the belt 508 has two recorded tones, one tone recorded at a first frequency, and one tone recorded at a second frequency. Once thetwo-tone signal is digitized and provided to the MPU 406, the MPU determines the speed of the tape by measuring the frequency of the tones. When the tape is in slow motion corresponding to play (or record) mode, the tones will have a relativelylower frequency. When the tape is in high speed, corresponding to fast-forward or rewind, the tones will have a relatively higher frequency. The direction of travel of the belt 508 is determined by comparing the phase difference between the two tones.

Alternatively, the belt 508 ispre-recorded with a single tone during a first time period, a second time period, and a third time period. By varying the lengths of the three time periods, the MPU 402 determines the direction of tape travel by looking for one of two expected patterns corresponding to first, second, third or third, second, first.

Again, as in the previous embodiment, the MPU 402 determines actual speed of the tape by measuring the frequency of the tone. The embodiment shown in Figure 6B consumes relativelyless power than the embodiment shown in Figure 6A because there is no optical sender 601. In Figure 6B, the read head 610 is a passive device that produces a signal that only needs to be amplified and digitized to be useful to the MPU 402.

The embodiments shown in 6A and the embodiment shown in 6B are not mutually exclusive. Figure 6C shows an embodiment that uses both the optical sender 601, the optical receiver 602, and a read head 620. In the embodiment shown in Figure 6C, the read head 620 is positioned close to thespool 504 and the spool 504 either has small magnets embedded in it or has a magnetic tape wrapped around it. The MPU 402 senses signals produced by the read head 620 to determine that thespool 504 (and therefore the belt 508) is in motion. When the MPU 402 senses that the belt 508 is in motion, the MPU 402 provides power to the optical sender 601 and uses the method described in Figure 6A to determine tape speed and direction. Alternatively, the MPU 402 determines tape speed and direction by examining signals produced by the read head 620. In this embodiment, one or twosmall magnets such as magnet650-652 shown in Figure 6C produce asmall pulse each time a magnet passes close to the read head 620. By

examining the order in which the pulses are produced, the direction of travel can be ascertained. The polarities of the pulses are varied by orienting the north and southpoles of the magnets650-652 to produce a discernible pattern of pulses from the read head 620. For example, if the magnets 650 and 651 are both oriented with their northpoles facing a desired direction and the magnet 652 is oriented with its south pole facing the same direction, then when the belt 508 is travelling forward the MPU 420 will sensenorthlnorthlsouth, and when thebelt 508 is travelling in reverse the MPU 420 will sensesouthinorthinorth.

The direction of travel can also be ascertained by distributing the magnets650-652 in an uneven pattern around the takeup spool 504.

Another embodiment of the motion sensor system 610 is shown in Figure 7. The system shown in Figure 7 does not use the belt 508. Rather, the takeupspool 504 is provided with a sensor 704 and a brake 710. The takeup spool 506 is provided with a sensor 702 and a brake 712. A small loop 709 of tape or plastic is provided between the pinchroller 518 and the capstan 520. The loop 709 is provided with a motion sensor 708. The motion sensors 704, 702, and 708 can be opticalandlor magnetic motion sensors as described in connection with Figures 6A-6C.

The brake 710 is provided to inhibit rotation of the take-upspools 506. Similarly, the brake 712 inhibits rotation of the take-up spool 504. In one embodiment, the brake 710 is a friction device, much like the brake on an automobile. When instructed by the MPU 402 to engage, the brake 710 creates friction against the take-up spool 506 causing thespool 506 to stop rotating.

In one embodiment, the brake 710 is a ratchet-like mechanism having a toothed wheel attached to the takeup spool 504 and apawl. The pawl iscontrolled by the MPU 402. The rotation of the take-up spool 504 is inhibited when the MPU 402 causes the pawl to engage teeth in the toothedwheel. In one embodiment, the MPU 402 selectively instructs the pawl to inhibit rotation of thetake-up spool 504 in a selected rotational direction (e. g., aclockwise direction)while still allowing relatively uninhibited rotation of thetake-up spool 504 in an opposite rotational direction (e. g., acounter-clockwise direction).

The read head 620 and magnets 650-651 form a system similar to a permanent magnet motor. It is well known that a permanent magnet motor acts as a generator when the motor shaft is driven by an external force. In one embodiment of the motion sensor system shown in Figure 7, the sensors 704 and 702 are permanent magnet motors that are coupled to the takeupspools 504 and 506 respectively. When the tape deck 106 spins the takeup spool 504, the sensor 704 (a permanent magnet motor) generate a voltage that isproportional to the speed of rotation of the spool 504. The generated voltage is sensed by the MPU 402. The generated voltage can also be supplie to the power control system 430 tohelp provideelectrical power to the electronic cassette. A similarprocess occurs the tape deck 106 spins the takeup spool 506.

User Interface

During fast-forward or rewind mode, the MPU 402 can desirably generate a beep signal when it switches from one sound file to another sound file. The beep signal is digitally generated by the MPU 402 or the DSP 404.

Alternatively, a text-to-speech module in the MPU 402 or the DSP 404 is used to generate an audio representation of the sound file. For example, in one embodiment, the user provides a textual description of the name of a song (or songs) or material stored in a soundfile. In fast-forward or rewind mode, when the MPU 404 switches from one sound file to the next, the MPU 402 picks up the stored text description, converts the information into speech, andplays that speech through the player 106.

In fast-forwardirewind mode, the MPU 402, in addition to providing a beep (or speech description), can provide a shortdelay when switching from song to song. The shortdelay gives the user time to push the play button on the tape player 106.

As discussed above, a computer program runs on the computer 104 to provide capabilities such as editing sound files, downloading sound files to the electronic cassette 100, uploading sound files from the electronic cassette 100, and generally managing the operation of and data stored on the electronic cassette 100. In one embodiment, the user program provides a list of available sound files and allows the user to select the sound files that will be copied onto the electronic cassette 100.

In one embodiment, the user program collects sound files into various groups (e. g. albums) and allows the user to synchronize the data on the electronic cassette 100 with the data in the groups. The user can group songs into various groups and download a particular group onto the electronic cassette 100. As the user changes the sound files in aparticular group, the user programsynchronizes the sound files on the electronic cassette 100 such that the group in the computer 104 matches the group in the electronic cassette 100. When synchronizing the electronic cassette 100 to the computer100, the program downloads sound files to the electronic cassette 100 and deletes sound files on the electronic cassette 100 as needed.

The user program also verifies and maintains the attributes (e. g., enableldisable status, order in the playlist, textual descriptions, etc.) of sound files on the computer 104 and the electronic cassette 100. Thus, for example, if a particulargroup"A"has sound files 1,2, and 3 and the user diables sound file 2, the status of the sound file 2 will be reflected on both the electronic cassette 100 and in the computer 104. If the user downloads a group B onto the

electronic cassette 100 and later reloads the group A onto the cassette 100, the user program will remember that sound file 2 was disabled in group A and it will keep sound file 2disabled when it reloads group A.

If the user uses the controls on the electronic cassette 100 to reorder the playlist or otherwise change the attributs of a sound file stored in the electronic cassette 100, the user program running on the computer 100 will sense this new order and modify the description of the group on the computer 100 to reflect the ordering and status of the group on the electronic cassette 100.

The display 302 is optional. On versions of the electronic cassette 100 that do not incorporate the display 302 the user program running on the computer 100typically provides the most convenient means for viewing the list of sound files, reordering the playlist, andgenerally manipulating the sound files found on the electronic cassette 100.

Temporary Storage of Sound Files
Various artists and industry recording groups continue to be concerned about the proliferation of songs provided in digital format and the ability make digital copies without losing sound quality. The problem of piracy in the electronic recording media has spawnedseveral lawsuits and continues to drive the industry's need for new technology. In one embodiment, the electronic cassette 100 includes a security access code and the electronic cassette 100 includes a playback counter for each sound file stored in thesound-file memory 414. Access to the playback counters is enabled by providing the security access code. Using an encryption system, such as, for example, a public key encryption system, a retailer holding the proper security access code can download a protected sound file into the electronic cassette 100 and limit the number ofplays provided for the protected sound file. Using this feature, a retailer can download digital sound material into a user's electronic cassette 100 and limit the number ofplays- thereby providing a trial period similar to the rental market for VCR tapes. The user is able to take the electronic cassette 100 home, play the protected sound file the allowed number of times and then the protected sound file is automatically deleted by the MPU 402. The protected sound files are restricted such that the MPU 402 will not upload the protected sound files into the user's personal computer 104.

In another embodiment, the MPU 402 provides a clock module that keeps track of the date and time. By using the clock module, the retailer can download a protected sound file into the electronic cassette for a specified period of time. When the time period runs out, the protected sound file is automatically deleted by the MPU 402.

Materials stored in the electronic cassette 100 in a protected mode can be played by the user for the allowed number of times or the allowed number of days. Protected sound files can also be deleted by the user. But, the protected sound files cannot beuploaded by the user from the electronic cassette 100 into another electronic cassette 100 or to the personal computer 104.

Although the foregoing has been a description and illustration of specific embodiments of the invention, various modifications and changes can be made thereto by persons skilled in the art, without departing from the scope and spirit of the invention as defined by the claims which follow.

ELECTRONIC CASSETTE APPARATUS AND METHOD

Claims of **WO0060599**

WHAT IS CLAIMED IS:
1. An electronic digital-audio cassette configured to be used in a conventional magnetic tape cassette player, said digital-audio cassette comprising:
an externalshell that issubstantially similar to an external shell of a standard compact cassette;
a memory configured to store digital audio sound files;
a control processor configured to control operation said digital-audio cassette;
a digital signal processor configured to convert data from said digital-audio sound files into a stream of digital-audio samples;
a digital-to-analog converter configured to convert said digital-audio samples into an analog signal; and
a transducer configured to convert saidanalog signal into atime-changing magnetic field connectable to a conventional analog cassette tape player.

2. The electronic digital-audio cassette of Claim 1, further comprising a display.

3. The electronic digital-audio cassette of Claim 1, further comprising a plurality of user controls.

4. The electronic digital-audio cassette of Claim 1, further comprising a computer interface.

5. An apparatus comprising:
a shell configured to have an external form factor that is compatible with an external form factor of a standard analog tape cassette; and
a processor coupled to a memory.

6. The apparatus of Claim 5 further comprising a take-up spool and a tape motion sensing system.

7. The apparatus of Claim 6, wherein said motion sensor is configured to sense a direction of motion and a speed of motion of saidtake-up spool.

8. The apparatus of Claim 6, further comprising a brake configured to inhibit a motion of saidtake-up spool.

9. The apparatus of Claim 6, further comprising a brake configured to inhibit a motion of saidtake-up spool in a selected rotational direction.

10. The apparatus of Claim 5, further comprising a display.

11. The apparatus of Claim 5, further comprising a plurality of user controls.

12. The apparatus of Claim 5, further comprising a power control system.

13. The apparatus of Claim 5, further comprising a computer interface.

14. The apparatus of Claim 13, wherein said interface is a universal serial bus interface.

15. The apparatus of Claim 13, wherein said interface is a fire-wire bus interface.

16. The apparatus of Claim 5, wherein said processor is configured todecompress audio information stored ina compressed audio format.

17. The apparatus of Claim 5, wherein said memory is configured to store digital data comprising digital-audio sound files.

18. The apparatus of Claim 17, wherein said digital-audio sound files are stored in a compressed format.

19. The apparatus of Claim 5 further comprising a display configured to list audio information stored in said memory.

20. An apparatus comprising:
a shell configured to have an external form factor that is compatible with an external form factor of a standard analog tape cassette;
a processor; and
a tape motion sensing system configured to senseplay, fast-forward, and reverse tape motions.

21. The apparatus of Claim 20, further comprising a brake configured to inhibit tape motion.

22. The apparatus of Claim 20, further comprising a brake configured to inhibit tape motion in a selectable direction.

23. The apparatus of Claim 20, further comprising a memory configured to store one or more digital audio sound files.

24. The apparatus of Claim 23 further comprising a display configured to list said one or more digital audio sound files.

25. The apparatus of Claim 20, further comprising a computer interface.

26. An apparatus comprising:
a processor coupled to a memory, said memory configured to store digital audio data;
adigital to analog converter configured to receive output digital audio samples from said processor in response to a tape motion command;
a transducer configured to produce atime-changing magneticfield in response to an analog signal produced by said digital-to-analog converter.

27. The apparatus of Claim 26, wherein said transducer is further configured to generate an analog signal in response to a time-changing magneticfield, said apparatus further comprising an analog-to-digital converter configured to produce input digital samples in response to an analog signal from said transducer.

28. The apparatus of Claim 27, wherein said processor is further configured to format said input digital audio samples into formatted data in a digital-audio sound file format and store said formatted data in said memory.

29. The apparatus of Claim 28, further comprising a computer interface configured to download data into said memory and upload data from said memory.

30. A digital storage device configured toplay digital-audio data in an analog cassette tape player.

31. A digital storage device configured to record digital-audio data using a standard analog cassette tape recorder.

32. A method for playing digital-audio files on an analog cassette tape deck comprising the steps of:
storing digital-audio data in a memory;
sensing mechanical motions generated by a cassette tape deck;
converting said digital-audio data into atime-changing magnetic field; and
providing said time-changing magnetic field to a read head in a cassette tape deck.

33. The method of Claim 32, further comprising the step of sensing tape motion commands from said tape deck.

34. The method of Claim 33, wherein said step of converting is performed in response to a play command.

35. The method of Claim 33, further comprising the step of scanning forward through said digital-audio data in response to a fast-forward command.

36. The method of Claim 35, further comprising the step of activating a brake when said step of scanning forward reaches an end of said digital audio data.

37. The method of Claim 33, further comprising the step of scanning backward through said digitalaudio data in response to a rewind command.

38. The method of Claim 37, further comprising the step of activating a brake when said step of scanning backward reaches a beginning of said audio data.

39. A method forplaying digital-audio files comprising the steps of:
extracting digital data from a memory in response to a slow tape forward command;
formatting said digital data into a stream of digital samples;
converting said digital samples into an analog signal;
inducing atime-changing magnetic field in a tape read head in response to said analog signal.

40. The method of Claim 39, further comprising the step of displaying information about said digital data on a display.

41. The method of Claim 40, further comprising the step of organizing said digital data into a play list.

42. The method of Claim 41, wherein said step of organizing includesdisabling a portion of said digital data.

43. The method of Claim 41, wherein said step of organizing includesenabling a portion of said digital data anddisabling a portion of said digital data.

44. The method of Claim 43, wherein said step of organizing includes rearranging portions of said digital data.

45. The method of Claim 39, further comprising the step of fast-forwarding through said digital data in response to a fast tape forward command.

46. The method of Claim 45, wherein said step of fast forwarding comprises performing the steps of formatting, converting, and inducing, on portions of said digital data.

47. A vehicle audio system comprising a memory interface configuredto read digital-audio data from a solid state floppy disk card.

48. The car audio system of Claim 47, wherein said digital audio data is stored in a compressed data format.

49.-An apparatus comprising:
a shell configured to have an external form factor that is compatible with an external form factor of a standard analog tape cassette;
storage means for storing digital data; and
playback means for converting said digital-audio data into atime-changing magnetic signal and coupling saidtime-changing magneticfield to a tape read head.

50. The apparatus of Claim 49, further comprising a tape-motion sensing system.

51. The apparatus of Claim 50, further comprising a display configured to display information about said digital data.

52. The apparatus of Claim 51, further comprising a user control system configured toallow a user to organize said digital data.

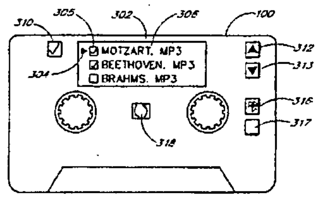

FIG. 3

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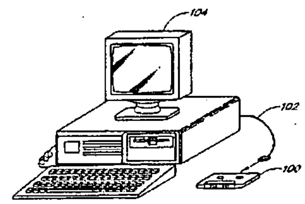

FIG. 1A

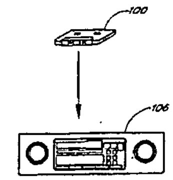

FIG. 1B

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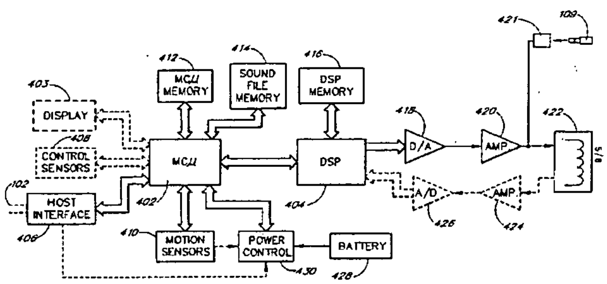

FIG. 4

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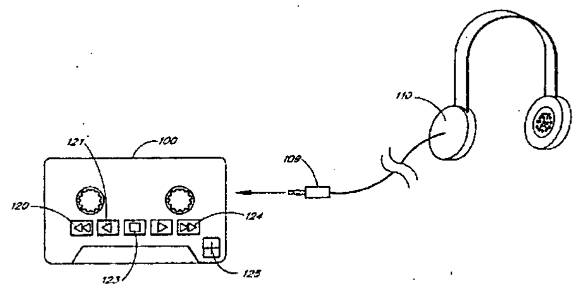

FIG. 1C

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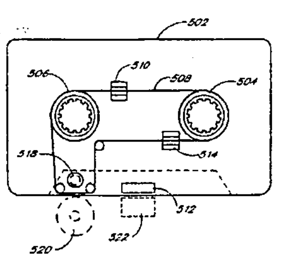

FIG. 5A

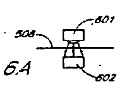

FIG. 6A

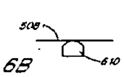

FIG. 6B

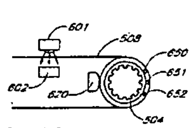

FIG. 6C

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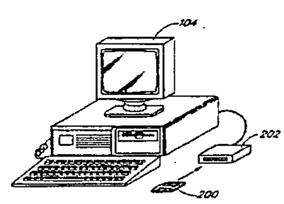

FIG. 2A

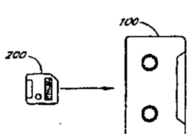

FIG. 2C

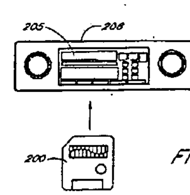

FIG. 2B

3/8

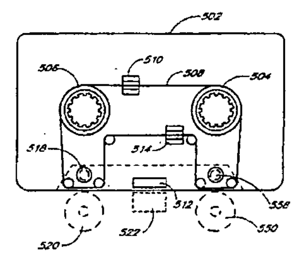
502
510
508
506
504
514
518
512
558
522
520
550

FIG. 5B

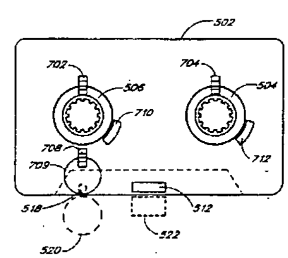
502
702
704
506
504
710
708
709
712
518
512
522
520

FIG. 7